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GENERAL DYNAMICS | CONVAIR

Report No. 8926-128

Material - Nickel Base Alloy - Monel Metal

Countersunk Rivet Shear Strengths

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Countersunk Rivet Shear Strengths

Abstract:

The ultimate and yield strength of AN427 Monel metal 5/32 and 3/16 inch diameter rivets driven into various thicknesses of Ti 6Al-4V alloy sheet were determined. Rivet installations in sheet thicker than 0.060 inch failed by rivet shear. Those joints which contained sheet material of less than 0.060 inch thickness failed by tear-out or crushing under the rivet. The ultimate and yield strengths of those rivets which failed in shear were: 3/16 inch diameter, 1781 and 2726 lbs. respectively; and 5/32 inch diameter, 1590 and 1985 lbs. respectively.

Reference: Neary, J. K., Buehler, H. A., Wise, W. E. "Monel Rivet - Machine Countersunk in Titanium Sheet - Design Ultimate Shear Test," General Dynamics/Convair Report MP 57-651, San Diego, California, 10 June 1958 (Reference attached).

CONVAIR
A DIVISION OF GENERAL DYNAMICS CORPORATION
SAN DIEGO

STRUCTURES & MATERIALS LABORATORIES

REPORT 57-651
DATE 10 June 1958
MODEL 22

TITLE

REPORT NO. 57-651
MONEL RIVET - MACHINE COUNTERSUNK IN TITANIUM SHEET
DESIGN ULTIMATE SHEAR TEST
MODEL 22

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NO. OF DIAGRAMS 3

REVISIONS

NO.	DATE	BY	CHANGE	PAGES AFFECTED
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FORM 1812A-4

INTRODUCTION:

The higher performance characteristics of modern aircraft necessitates aerodynamically clean skin surfaces. In the past, countersunk rivet installations in thin sheet thicknesses were made by dimpling, a method which produced uneven skin surfaces. In an attempt to produce smoother skin surfaces, dimpled rivet installations are being replaced with countersunk installations.

Since the thin skin thicknesses now being countersunk are less than the minimum allowable per present installation specifications, allowable rivet loads are not available for structural design.

OBJECT:

The object of this test is to determine the design allowable load of AN 427 monel rivets in machine countersunk titanium sheet.

CONCLUSIONS:

Design ultimate shear loads for AN 427 monel rivets in machine countersunk titanium sheet, are as follows:

Diameter of Rivet	5/32"	3/16"
Sheet Thickness		
.040"	732 Lb.	1280 Lb.
.055"	705 Lb.	1533 Lb.
.073"	863 Lb.	1188 Lb.

TEST SPECIMEN:

Test specimens were riveted lap joints, two rivets at each joint, using AN 427 MC monel rivets in machine countersunk, mill annealed, 6 Al - 4V titanium sheet. Specimen dimensions and rivet spacing are shown in Table I and Figure 1 respectively. Specimens having skin thickness less than the .060 minimum, per Q 2001, were countersunk to the depth necessary to maintain the specified countersink diameter. This resulted in the countersink projecting through the top and into the bottom sheet, greatly reducing the bearing area.

TEST PROCEDURE:

The riveted specimens were tested in a 12,000 pound Tinius-Olsen test machine. Load was applied in increments which produced a joint elongation of .005 inch and reduced to a tare of 25 pounds, after each load increment, to determine permanent set. After yield was determined, the load was increased until failure occurred.

Joint elongation was measured with a dial gage extensometer over a 2 inch gage length (Reference Figure 1).

Tensile coupons were removed from all titanium sheet tested to determine if the mechanical properties were within design specifications.

RESULTS:

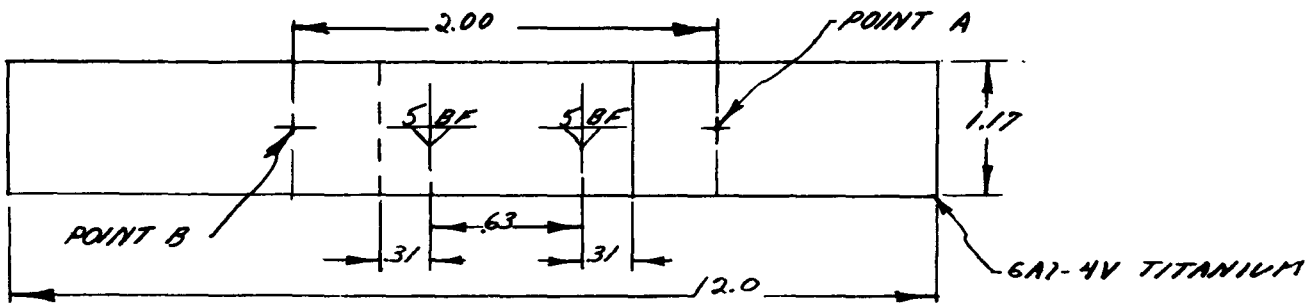
Test results from all specimens and coupons are presented in Table I. Photographs of typical test specimen failures are shown in Figures 2 and 3. Modes and sequences of failures were as follows:

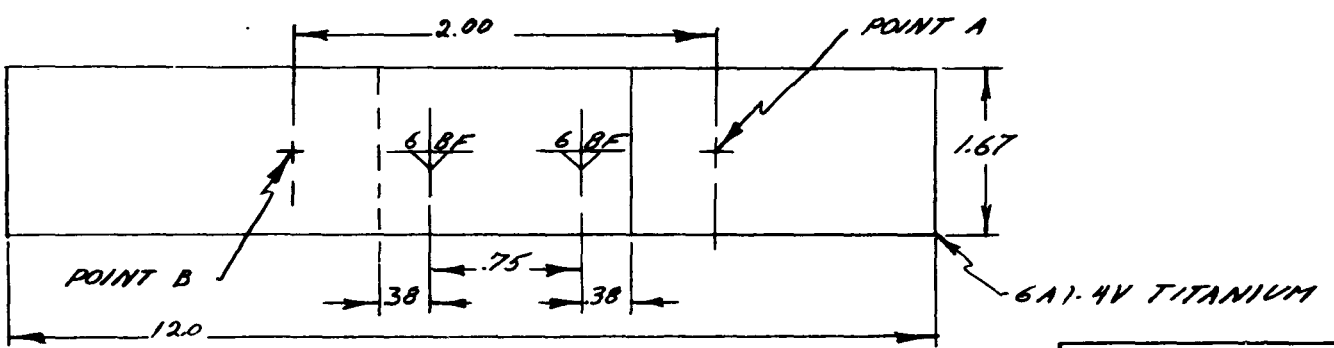
RIVET DIA. In.	SKIN THICK In.	TYPICAL FAILURES (Reference Figures 2 and 3)
3/16	.040	Tear out of countersunk skin.
5/32 3/16 5/32	.040 .055 .055	Primary bearing failure of countersunk skin followed by a secondary combined shear-tension failure of the rivet.
3/16 5/32	.072 .072	Shear failure of the rivets.

NOTE:

The test data from which this report was prepared are recorded in Structures Test Laboratory Data Book No. 4003, pages 131-144.

TEST SPECIMENS





NOTE:
(1) DRILL & MACH. C'SINK. PER Q2001 WITH FOLLOWING EXCEPTION:
(A) MINIMUM SKIN THICKNESS, (E), (REF. Q 2001), WILL NOT BE MAINTAINED. COUNTERSINK DEPTH WILL BE ADEQUATE TO MAINTAIN COUNTERSINK DIAMETER, (B) (REF Q 2001)
(2) CAA. & CONVAIR INSPECTION WILL BE REQUIRED PRIOR TO & AFTER RIVETING.

STRUCTURAL TEST
CONVAIR - SAN DIEGO
A DIVISION OF GENERAL DYNAMICS

TITLE			
TEST SPECIMENS 100° MONEL RIVETS MACH. C'SK IN 6A1-4V TITANIUM SHEET			
MODEL	SCALE	DATE	DRAWN BY
22	NONE	2/24/58	NEARY
S.O.		DRAWING NUMBER	
W.O.		FIGURE 1	

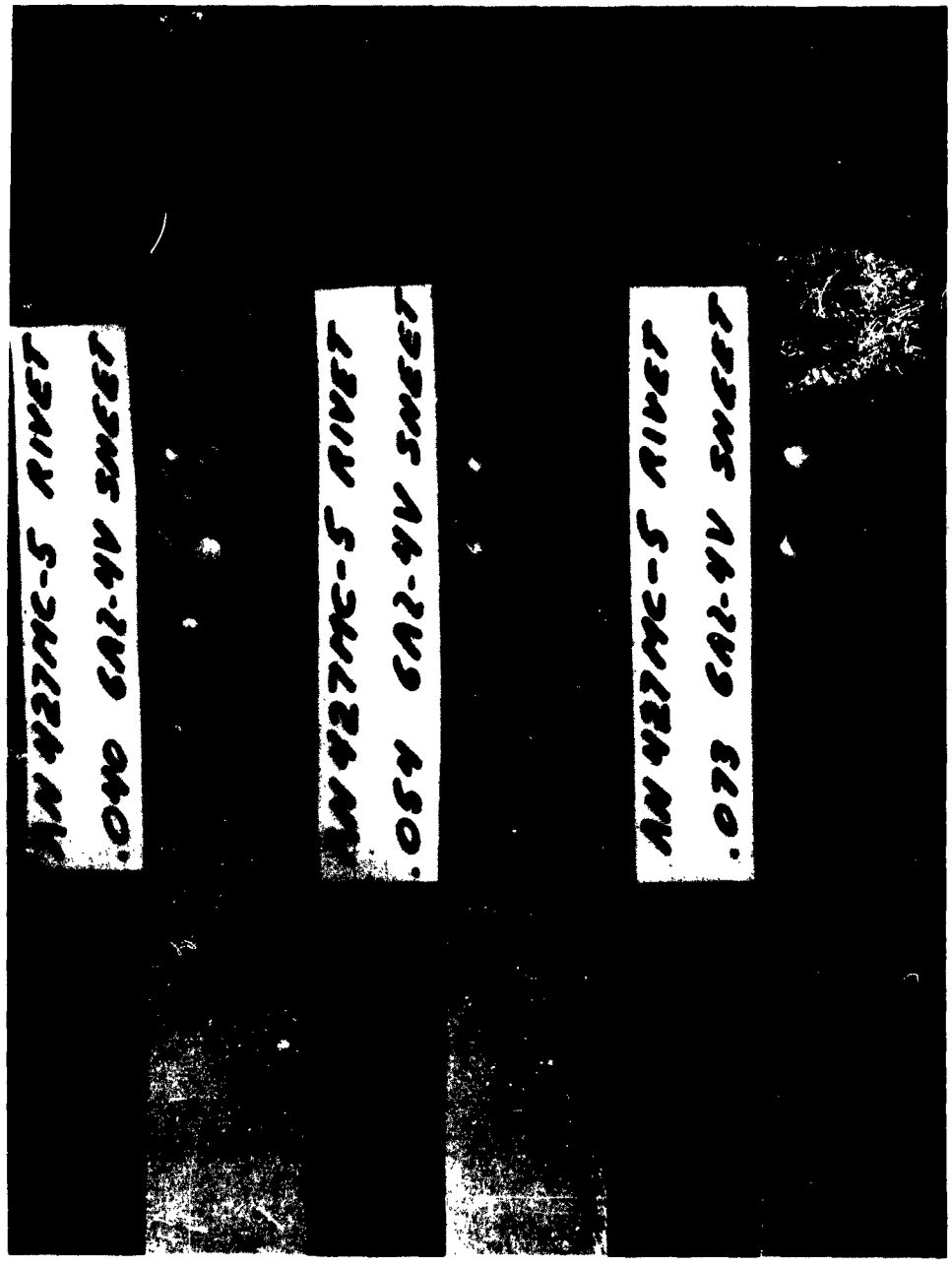


Figure 2 SPECIMEN FAILURE - 5/32 DIA. RIVET

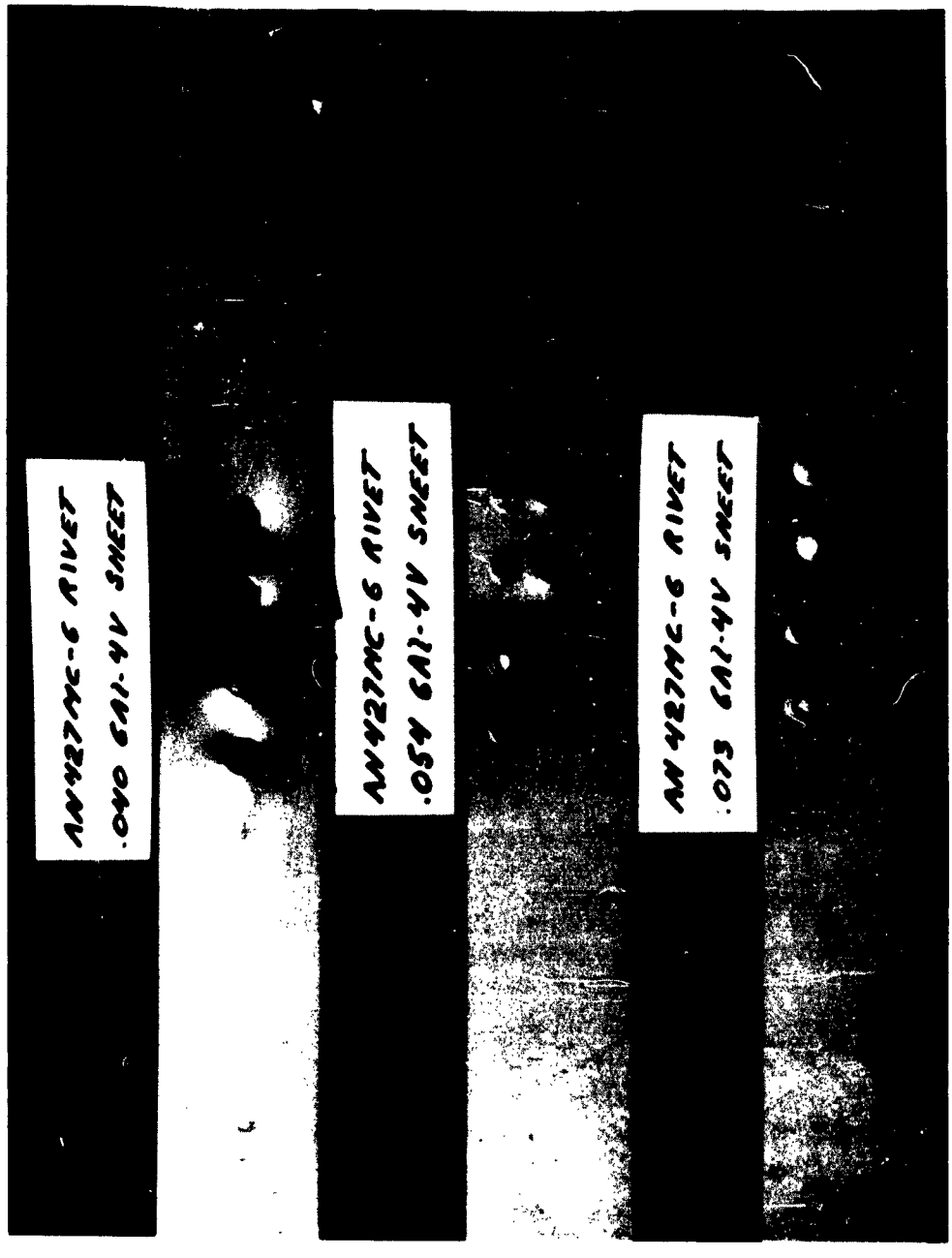


Figure 3 SPECIMEN FAILURE - 3/16 DIA. RIVET

TABLE I - SPECIMEN DIMENSIONS & TEST RESULTS

SPECIMEN NUMBER	MATERIAL THICKNESS ~IN.	RIVET DIAMETER ~IN.	HOLE DIA. (REF. FIG 1) D_2 ~IN.	C'SUNK DIA (REF FIG 1) D_1 ~IN.	COUPON DATA: TENS. YIELD ~LB/IN²	COUPON DATA: TENS. ULT. ~LB/IN²	COUPON DATA: % ELONG. 2" LENGTH	TEST YIELD * ~LB.	TEST ULT. ~LB	DESIGN ULT. ** ~LB.
4011	.039	3/16	.190	.35	120492	131247	13.00	1750	2920	
4021	.040		.190	.35				1780	2940	1282
4031	.040		.192	.35				1310	2855	
4041	.040	3/16	.191	.35	120492	131247		2000	3115	
4072	.040	5/32	.163	.29	119597	130653		1050	2265	
4082	.041		.164	.28				910	2190	731
4092	.037		.164	.29				1020	2285	
4002	.040	5/32	.164	.29	119597	130653	13.06	920	2255	
5511	.054	3/16	.192	.34	130151	142463	12.75	2170	3440	
5521	.054		.192	.34				2050	3445	1533
5531	.054		.193	.34				2100	3505	
5541	.054	3/16	.190	.34	130151	142463	12.75	2170	3510	
5562	.054	5/32	.164	.28	127250	140480	11.50	1180	1625	
5572	.054		.164	.28				1200	1620	705
5582	.054		.164	.29				1280	1600	
5502	.054	5/32	.164	.29	127250	140480	11.50	1220	1645	
7511	.073	3/16	.191	.36	126108	133663	14.75	1720	2745	
7521	.073		.190	.36				1675	2650	1185
7541	.073		.191	.36				1860	2730	
7552	.073	3/16	.191	.36	126108	133663	14.75	1870	2780	
7562	.074	5/32	.164	.29	125476	133602	15.00	1610	1990	
7572	.074		.164	.29				1550	1905	863
7582	.074		.164	.28				1660	2060	
7592	.074	5/32	.164	.28	125476	133602	15.00	1540	1985	

NOTE:

* LOAD WHICH PRODUCED A PERMANENT SET OF .005 IN. OVER A 2.00 IN. GAGE LENGTH

** AVERAGE TEST ULTIMATE LOAD DIVIDED BY 1.15 OR THE AVERAGE TEST YIELD TIMES 1.50, WHICH EVER IS LEAST